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Method and device for conditioning semiconductor wafers and/or hybrids

The present invention relates to a method and a device for conditioning semiconductor wafers and/or hybrids.

It is known to carry out test measurements on semiconductor wafers typically in a temperature range between -200°C and +400°C. For the heat treatment a semiconductor wafer is applied to a sample stage which is cooled and/or heated according to the desired temperature. In the process it is necessary to ensure that the temperature of the semiconductor wafer does not drop below the dew point of the surrounding gaseous medium since otherwise moisture condenses on the surface of the wafer or icing occurs, which impedes or prevents the test measurements.

Fig. 5 shows a schematic cross-sectional view of a conditioning device for the purpose of explaining the problems on which the present invention is based.

In Fig. 4, reference symbol 1 designates a space in a container 5 in which a sample stage 10 which can be temperature controlled is provided and on which a semiconductor wafer (not shown) can be positioned for test purposes. The volume of the container 5 is usually between 400 and 800 litres.

The space 1 is enclosed essentially by the walls of the container 5 which have bushings for electrical lines and media supply lines as well as, if appropriate, bushings for probes which are to be attached externally and with which the test measurements semiconductor wafer shown are to be carried out. However, this space 1 must not be hermetically sealed by the

container 5 depending on the application but must at least be enclosed to such an extent that undesired penetration of moist ambient air can be prevented by building up an internal excess pressure.

The sample stage 10 (also referred to as chuck) has a thermal insulation 15 via which it is connected to a usually movable base 20. A corresponding movement mechanism (not shown) is generally adjustable in the X, Y and Z directions. If the movement mechanism is not located in the container, a seal has to be provided between the base and container.

Furthermore, a heating device 90, which can be supplied from the outside with electrical current for heating purposes and which has a temperature probe (not shown), is integrated into the sample stage 10.

Reference symbol 100 designates a dew point sensor by means of which the dew point within the container 5 can be determined and which can supply a corresponding signal to a monitor 101 outside the container 5. The dew point sensor 100 is used in particular for the sake of reliability when opening the device so that, for example, compensatory heating can be carried out in order to avoid condensation of water.

Furthermore, outflow elements 30 (oBdA. only two are shown) via which dried air from outside, or a similar fluid such as, for example, nitrogen, can be introduced via a line r1 into the container in order to drive out moist ambient air from the container 5. This air is firstly fed externally to an air drier 3 via a line r00 and then fed into the line r1.

A separate unit, which is connected to the container 5 via a corresponding electrical line 11 and a media supply line r2, is the temperature control rack 2 which

has the following devices.

Reference symbol 80 designates a temperature controller which can regulate the temperature of the sample stage 10 by heating by means of the heating device 90, the sample stage 10 simultaneously or alternatively being rinsed with air for cooling purposes, as is explained in more detail below.

Reference symbol 70 designates a temperature regulating device to which dried air is fed via the lines r0 and i1 from, for example, a gas bottle or from an air drier, and which has a heat exchanger 95 which is connected to cooling assemblies 71, 72 by means of which it can be cooled to a predetermined temperature.

The dried air which is fed via the lines r0, i1 is conducted through the heat exchanger 95 and then fed via the supply line r2 into the container 5 to the sample stage 10, through which it crosses in corresponding cooling coils or cooling pipes (not shown). The dried air which has cooled the sample stage 10 leaves it via the line r3 and is conducted out of the container 5 to the atmosphere.

The dried air, which is conducted into the container 5 via the outflow elements 30 in order to condition the atmosphere of the container 5 is usually kept at room temperature so that only the surface of the sample stage 10 is kept at the desired measuring temperature, for example -20°C, but the other elements in the container 5 are approximately at room temperature. This dried air which is fed via the outflow elements 30 flows out of the container 5 through slits or gaps (not shown) or a separate outlet line.

The fact that a relatively high consumption of dried air occurs because said air, on the one hand for

conditioning the atmosphere and on the other hand for cooling the sample stage 10, is blown through the container 5 and into the atmosphere, proves disadvantageous in this known device for conditioning semiconductor wafers. As a result, the consumption of dried air is relatively high. A failure of the air drier 3 also brings about immediate icing of the test wafer at corresponding temperatures.

For this reason, the object of the present invention is to specify a method and a device for conditioning semiconductor wafers and/or hybrids, which permit more efficient conditioning.

The method according to the invention having the features of Claim 1 and the corresponding device according to Claim 9 have, in comparison with the known solution approach, the advantage that the dried gas, for example the dried air, can be used efficiently. Further advantages are the high level of operational reliability and the fact that freedom from ice and condensation is ensured because the dry air leaving the wafer/hybrid holding device is always below the dew point of the temperature at the wafer/hybrid holding device.

The idea on which the present invention is based is that at least a portion of the gas leaving the wafer/hybrid holding device is used to condition the atmosphere within the space. In the present invention, cooling air is therefore used simultaneously at least partially as dry air. It is advantageous if the portion of gas is firstly heat-treated and then allowed to flow out within the space.

For example, the portion is heat-treated outside a container and then fed back to the container. A particular advantage of this example is that a higher

level of cooling efficiency is made possible by correspondingly feeding back the air from the sample stage to outside the container. In other words, the fed-back, cooled air can be additionally used either for precooling the fed-in dried air or for cooling specific assemblies and not only for cooling the wafer/hybrid holding device.

However, it is alternatively or additionally possible for a portion of the gas to be allowed to flow out within the container directly after it leaves the sample stage. Since it is not expedient to allow it to flow out directly at all temperatures, a corresponding regulating valve is to be provided for this portion of gas.

Advantageous developments and improvements of the respective subject matter of the invention are given in the subclaims.

According to one preferred development, the line device has a first line via which the fluid can be conducted from outside the space into the wafer/hybrid holding device, a second line via which the fluid can be conducted from the wafer/hybrid holding device to outside the space, and a third line via which the fluid can be fed back from outside the space into the space. A temperature regulating device is provided between the second and third lines.

According to a further preferred development, outflow elements are provided at the end of the third line.

According to a further preferred development, the line device has a first line via which the fluid can be conducted from outside the space into the wafer/hybrid holding device, and a fourth line via which the fluid can be conducted from the wafer/hybrid holding device

into the space.

According to a further preferred development, the line device has a second line via which the fluid can be conducted from the wafer/hybrid holding device to outside the space, and a third line via which the fluid can be fed back into the space from outside the space. A temperature regulating device is provided between the second and third lines.

According to a further preferred development, a valve is provided for regulating the flow rate of the fourth line.

According to a further preferred development, the temperature regulating device has a heating device.

According to a further preferred development, the temperature regulating device has a heat exchanger to which at least a portion of the fluid leaving the space can be conducted.

According to a further preferred development, the heat exchanger is used to precool the fed-in fluid.

According to a further preferred development, the line device is designed in such a way that the portion leaving the heat exchanger can be fed back at least partially into the space in order to condition the atmosphere.

According to a further preferred development, a further line is provided via which dry fluid can additionally be conducted directly into the space from outside the space.

According to a further preferred development, the space is essentially enclosed by a container.

Exemplary embodiments of the invention are illustrated in drawings and will be explained in more detail in the following description. In said drawings:

Fig. 1 is a schematic illustration of a first embodiment of the conditioning device according to the invention;

Fig. 2 is a schematic illustration of a second embodiment of the conditioning device according to the invention;

Fig. 3 is a schematic cross-sectional view of a third embodiment of the conditioning device according to the invention;

Fig. 4 is a schematic cross-sectional view of a fourth embodiment of the conditioning device according to the invention; and

Fig. 5 is a schematic cross-sectional view of a conditioning device for the purpose of explaining the problems on which the present invention is based.

In the figures, identical reference symbols designate identical or functionally identical components.

Fig. 1 is a schematic illustration of a first embodiment of the conditioning device according to the invention.

In what follows, components which have already been described above in conjunction with Fig. 5 will not be described again in order to avoid repetitions.

Reference symbol 80′ designates a modified temperature

controller which can not only regulate the temperature of the sample stage 10 by means of the heating device 90 but is also coupled to the dew point sensor 100 via a line 12 and can thus initiate automatic compensatory heating when there is a risk of condensation of water/icing.

In the first embodiment according to Fig. 1, a heating device 105 is additionally integrated into the temperature regulating device 70 and is not in direct contact with the heat exchanger 95. Instead of ending at the ambient atmosphere, the line r3 is conducted to the heating device 105 so that the dry air which has left the sample stage 10 is, as it were, fed back to the temperature control rack 2 and after it has passed through the heating device 105 it is conducted back via the line r4 to the container 5 in which it flows out into the space 1 through outflow elements 40 for conditioning the atmosphere.

The reference symbol 4 designates a temperature sensor for sensing the temperature in the space 1, which sensor supplies a corresponding temperature signal TS to the temperature regulating device 70 which is used to regulate the temperature by means of the heating device 105.

By virtue of this arrangement, the dried air can fulfil a double function, specifically firstly cool the sample stage 10 and then condition the atmosphere of the space 1 before it is fed back to the ambient atmosphere through openings in the container 5, and is thus used more effectively.

Fig. 2 is a schematic illustration of a second embodiment of the conditioning device according to the invention.

In the second embodiment according to Fig. 2, a line r5 branches off from the line r2 directly before the sample stage 10 and is also conducted through the sample stage 10 in the form of a cooling coil or a cooling pipe, but then leaves the sample stage 10 at a different point from that of the line r3 and from there via a controllable outlet valve 45 which conducts corresponding dried air directly into the container 5 after it leaves the sample stage 10.

Since this would lead to problems at very low temperatures in certain applications, this option of conducting the dry gas via the line r5 into the container 1 can be regulated by means of the outlet valve 45. The regulation can be carried out in a customary way, for example by remote control or in a wire-controlled fashion.

Otherwise the second embodiment is of identical design to the first embodiment described above.

Fig. 3 shows a schematic cross-sectional view of a third embodiment of the conditioning device according to the invention.

Reference symbol 80′ designates a further modified temperature controller which also controls the temperature regulating device 70 via the control line ST and thus plays the role of a central temperature control system.

In the third embodiment according to Fig. 3, a portion of the dry air which is fed back via the line r3 is branched off before the heating device 105 via line i3 and conducted through the heat exchanger 95 where it contributes to the cooling in the same way as the dry air which is freshly fed in via the lines r0, i1. The dry air leaves the heat exchanger 95 via the line i4,

and directly after the heating device 105 it is combined with the air which has flowed through the heating device 105. From the corresponding junction point, this dried air is conducted, in precisely the same way as in the first embodiment, via the line r4 and the outflow elements 40 into the container 5 for conditioning its atmosphere.

Furthermore, this embodiment provides a controllable mixing valve 46 and a bypass line r10 by means of which the heat exchanger 95 can be bypassed.

The particular advantage of this embodiment is that a "residual coldness" of the dried air which flows back from the sample stage 10 can be used to cool the heat exchanger and at the same time can be fed back into the container 5 after heating.

Otherwise, the second embodiment is constructed in the same way as the first embodiment described above.

Fig. 4 is a schematic cross-sectional view of a fourth embodiment of the conditioning device according to the invention.

Reference symbol 85 in Fig. 4 designates an additional gas-temperature controller to which dry gas, for example dried air, is fed via lines r0, i2 from the same gas source as that of the heat exchanger 95, said air being placed at a predefined temperature by said controller and then conducted into the interior of the container 5 via the line r1 and via the outflow element 30.

The direct feeding in of dried air via the outflow element 30 in the container 5 is therefore additionally provided in this embodiment but it can also be configured in such a way that it can be switched off if

the throughflow rate through the sample stage 10 is completely sufficient for conditioning the atmosphere within the container 5.

Although the present invention has been described above with reference to preferred exemplary embodiments, it is not restricted to them but rather can be modified in a variety of ways.

In particular it is to be noted that the exemplary embodiments above can of course be combined with one another. Additional line connections and regulating valves for the respective gas flow, which can be controlled manually or electrically, can also be provided.

In addition, the residual coldness of the fed-back gas can be used not only for cooling the heat exchanger 95 but also for cooling any desired other assemblies or heat exchangers before said residual coldness is fed back to the container 5.

The invention is also not restricted to gaseous dried air but can in principle be applied to any other fluids.

Furthermore, the wafer/hybrid holding device is not restricted to a sample stage or chuck but rather can be varied as desired, for example as a clamp device or the like.